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(54) Incremental forming method and apparatus for the same

(57) In a state that the material (blank) cut in a predetermined shape is mounted on a die and the bottom of the material is supported by the seat, the material is pressed by the tool from above and moved along the die and the material is incrementally formed. The bottom of the material is fixed by the material, so that the material is not inclined and can be formed in a predetermined shape. The circular arc portion of the flange is processed in a state that it is clamped by the female die and the tool, so that the circular arc portion of the flange is not spread outside and the perpendicularity between the flange of the circular arc portion and the bottom can be increased.

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Description

Background of Invention:

<Technical Field>

[0001] The present invention relates to an incremental forming method for processing gradually a plate, and more particularly suitable to an incremental forming method for a molded product having a flange in an end portion of a plate.

<prior Art>

[0002] Conventionally, a molded product having a flange at an end portion of a plate is manufactured by inserting and pressing the plate between a female die and a male die. Since the female die and the male die are required, the price becomes high.

[0003] As a means for reducing dies, an incremental forming method is proposed as shown in Figs. 18 to 20 in Japanese patent application laid-open publication Hei 11-310371. This method is to fix an outer periphery of a material to a female die, press the material with a rod shape tool, move it along an inner peripheral face of the female die, and is carried out a sponson processing incrementally the plate. On the other hand, in Japanese patent application laid-open publication Hei 10-76321, a plate is carried out by a drawing processing.

[0004] The incremental forming method uses only one die, so that it is inexpensive. However, in a manner shown in the above stated Japanese patent application laid-open publication Hei 11-310371, when to an end portion of the plate a flange is formed, the plate is left at an outer peripheral portion of the flange. When this plate is unnecessary, it is necessary to cut off and remove the outer peripheral portion of the flange. Further, when the flange is formed according to this processing manner, an angle formed by the flange and a bottom plate is not formed with a rectangular angle. For example, when a cylinder is overlapped and joined to the flange, when the flange is not formed in a rectangular shape, it hardly to carry out an overlapping welding. Further, it is difficult to form a flange having a high height.

[0005] On the other hand, when the flange is formed according to the manner shown in Japanese patent application laid-open publication Hei 10-76321, the wrinkle occurs easily on a corner portion of the flange.

Summary of the Invention:

[0006] An object of the present invention is to provide an incremental forming method for easily forming of a plate in a predetermined shape.

[0007] The above stated object can be attained by an incremental forming method, wherein under a condition where a material is fixed to a seat arranged on an inner side of a female die, between the female die and a tool member and between the seat and the tool member, the material is arranged, and under a condition where an outer end portion of the material is capable to move in a drawing processing direction, the seat and the tool member are relatively moved in the female die according to a drawing processing direction, and the tool member is relatively moved along to an inner peripheral face of the female die.

Brief Description of the Drawings:

[0008]

Fig. 1 is a longitudinal cross sectional view of the essential section of a forming apparatus of one embodiment according to the present invention;
Fig. 2 is a perspective view showing the relationship between a die during forming, a female die, a rod shape tool, and an article to be processed;
Fig. 3 is a plan view showing the processing condition of the circular arc portion shown in Fig. 1;
Fig. 4 is a perspective view showing a molded product;
Fig. 5 is a plan view showing a material;
Fig. 6 is a plan view showing the circular arc portion of the molded product;
Fig. 7 is a VII-VII cross-sectional view of Fig. 6;
Fig. 8 is a VIII-VIII cross-sectional view of Fig. 6;
Fig. 9 is a explanatory view of a drawing processing of another embodiment according to the present invention;
Fig. 10 is a longitudinal cross-sectional view of the essential section of another embodiment according to the present invention;
Fig. 11 is a longitudinal cross-sectional view of the essential section of still another embodiment according to the present invention;
Fig. 12 is a longitudinal cross-sectional view of the essential section of a forming apparatus of another embodiment according to the present invention;
Fig. 13 is a longitudinal cross-sectional view of the essential section of a forming apparatus of still another embodiment according to the present invention;
Fig. 14 is a longitudinal cross-sectional view of the essential section of a further embodiment according to the present invention;
Fig. 15 is a longitudinal cross-sectional view of the essential section of a still further embodiment according to the present invention;
Fig. 16 is a plan view of the essential section of a further embodiment according to the present invention;
Fig. 17 is a side view of the material after forming shown in Fig. 16;
Fig. 18 is a perspective view of the molded product of another embodiment according to the present invention;

Fig. 19 is an explanatory view showing a manufacturing process of the molded product of Fig. 18;
Fig. 20 is a perspective view of the molded product of a further embodiment according to the present invention;
Fig. 21 is an explanatory view showing a manufacturing process of the molded product of Fig. 20; and
Fig. 22 is a perspective view of the molded product of a further embodiment according to the present invention.

Description of the Invention:

[0009] A first embodiment of an incremental forming method and an apparatus for the same according to the present invention will be explained by referring to from Fig. 1 to Fig. 5. Fig. 1 shows substantially only the left end portion of an apparatus and this apparatus is symmetrical one in right and left. Fig. 2 shows a condition during forming.

[0010] A molded product 10 has a bottom 11 and has a flange 12 on an outer peripheral portion thereof. The molded product 10 is composed of four sides, and the side is linear, and a corner portion 12a where the two adjacent sides are joined is in a circular arc shape. The face of the bottom 11 and the face of the flange 12 are almost perpendicular to each other. The molded product 10 can be used singly, in addition to this it becomes a cover of an end portion of the cylindrical member. When the flange 10 and the end portion of the cylindrical member are overlapped and fixed, it is desirable to form orthogonal the flange 12 and the bottom 11.

[0011] A die 20 is a female die (an outer die). The female die 20 is located horizontally. To an upper face of the female die 20, a plate 10b of the material is mounted. A rod shape tool 30 is inserted into an inner portion of the female die 20. The tool 30 moves down along to a perpendicular face of the female die 20 and then moves along to the inner peripheral face of the female die 20. A shape of the inner peripheral face of the female die 20 is substantially the same to an outer face shape of the molded product 10. When the tool 30 makes one revolution, the tool 30 repeats the above stated operation. By doing this, a flat plate 10b of the material is carried out the drawing processing. Moving the tool 30 down is referred to as moving it in the drawing processing direction. This is practically moving of the tool 30 in an axial direction and moving in a direction of a depth of the molded product 10.

[0012] A tip end of the tool 30 is flat. A corner portion from the tip end toward a side face is circular arc shape. The circular arc is a circular arc formed by the bottom 11 of the molded product 10 and the flange 12. The tool 30 is suspended from an upper mobile body (not shown in the drawing) so as to freely rotate. The tool 30 moves along the inner peripheral face of the female die 20 (corresponded to a portion of the flange 12). The tool 30 moves in contact with the material 10b, so that the tool 30 rotates on a following basis (a daily rotation). By doing this, the tool 30 does not touch the material 10b at one point, so that it can be prevented from seizing. Further, to the upper face of the material 10b, the lubrication oil is coated.

[0013] A plurality of pins (guides) 23 for positioning the material 10b are set on an upper face of the female die 20. When the flat plate of the material 10b is put on the upper end of the female die 20, the pins 23 are in contact with the outer peripheral portion of the material 10b. The material is positioned by it. The upper end of the female die 20 on the inner periphery side is circular arc shape. This circular arc is provided along to a whole periphery of the female die 20. By this circular arc, the outer peripheral portion of the material 10b smoothly moves on the inner periphery side of the female die 20.

[0014] In an interior portion of the female die 20 has no bottom. There is a seat 40 for mounting the material 10b inside the female die 20. The seat 40 is supported by a device 50 for controlling the height and position of the seat 40. There is another seat 40 also in a portion opposite to the tip end (the lower end) of the tool 30. The seat 40 is installed in the portion corresponding to the movement locus of the tool 30 in the peripheral direction. Namely, the material 10b is clamped by the tip end of the tool 30 and the seat 40. Furthermore, there is still another seat 40 also at the center of the female die 20. Therefore, the center portion of the material 10b can be fixed.

[0015] The seat 40 mounts (loads) and fixes the material 10b. This fixing is realized by the magnetic force of an electromagnet installed in the seat 40. Or, a vacuum adsorption pad is installed on the top of the seat 40 and the fixing is realized by a vacuum adsorption. The fixing position is the center portion etc. of the seat 40. The material 10b is an iron series, a stainless steel series, or an aluminum alloy series.

[0016] The device 50 for moving the seat 40 up and down will be explained hereunder. The device 50 is composed of a plurality of screw mechanisms 51. A pair of screw mechanism is shown in Fig. 1. A seat 45 at the lower end of the seat 40 is supported by a screw bar 52 of the screw mechanism 51. The seat 45 has a nut which can rotate freely. When a driving device 55 rotates, the screw bar 52 rotates and the seat 40 moves up. Between the seat 40 or the seat 45 and the base, a plurality of guides (not shown in the drawing) for the seat 40 to move up vertically are installed. The device 50 and the female die 20 are installed on the base (foundation).

[0017] The incremental forming method will be explained hereunder. Firstly, the flat-plate material (blank) 10b developed on the basis of the shape after the forming is prepared. Since the molded product 10 has a four-sided shape and has a circular arc part on a corner portion, as shown in Fig. 5, a plan view of the material 10b is substantially four-sided shape, and the corner portion thereof has the circular arc shape. The size and the shape of the material 10b and the shape of the circular

arc of the corner portion thereof are determined by taking into the consideration of the shape of the molded product 10. In the above stated development, the development dimensions are calculated on the basis of the surface area and the volume of the molded product in the same way as with the square cylinder drawing processing forming. On the basis of these development dimensions, a plate is cut off by a turret punch press.

[0018] Next, the material 10b is put on the tip end of the female die 20. In this time, the material 10b is also put on the seat 40 moving up. The material 10b is positioned by the pins 23.

[0019] Next, the material 10b is fixed to the seat 40. The fixing position and the means are as specified previously.

[0020] Next, the seat 40 is moved down and next the tool 30 is moved down. The lowering position of the tool 30 is the position where the material 10b can be positioned between the side face of the tool 30 and the vertical face (the inner peripheral face, the linear portion) of the female die 20. Namely, between the inner peripheral face of the female die 20 and the side face of the tool 30, the material 10b is clamped. With this condition, the tool 30 is descended, as stated in a latter portion, the tool is moved in the peripheral direction along to the inner peripheral face of the female die 20. The descendent amount of the tool 30 is a position where the tip end of the tool 30 is contacted to the descended material 10b. For example, before the seat 40 has descended, when the upper face of the seat 40 is positioned at the same position of the upper face (the position where the end portion of the material 10b is mounted) of the female die 20, and when the tip end of the tool 30 is contacted to the upper face of the material 10b, the descendent amount of the seat 40 and that of the tool 30 have the same amount. The seat and the tool can be descended at the same time.

[0021] When the bottom plate 11 is wide, and the plate thickness is thin, and the center portion of the bottom plate 11 is fixed, as shown in this embodiment, there is no need to bend the outer peripheral portion by the female die 20 because only the bottom plate 11 bends. Therefore, there is the possibility that the material 10b may be inclined. As described later, when the tool 30 is moved in the peripheral direction, there is the possibility that the material 10b may rotate. Therefore, the material 10b is fixed to the seat 40.

[0022] The descendent position of the tool 30 is the position where the flange 12 can be positioned between the side face of the tool 40 and the inner peripheral face of the female die 20. The perpendicularity (the angularity) of the flange 12 is taken into account. When perpendicularity of the flange 12 is taken into account, the tool 30 is positioned so as to clamp the material 10b between the side face of the tool 30 and the inner peripheral face of the female die 20.

[0023] Next, the tool 30 is moved along to the inner peripheral face of the female die 20. The tool 30 rotates on a following basis. The material 10b is incrementally formed by movement of the tool 30.

[0024] Next, whenever the tool 30 makes a round, as stated in above, the seat 40 is moved down and the tool 30 is moved down. The descendent distances of the two and the descendent position of the tool 30 are as specified previously. Next, the tool 30 is moved in the peripheral direction along to the inner peripheral face of the female die.

[0025] After that, the descendent of the seat 40 and the tool 30 and the movement of the tool 30 in the peripheral direction are repeated. By the repetition of the above stated steps, the outer peripheral portion of the material 10b moves to the inner peripheral face of the female die 20. Accordingly, the drawing processing is carried out. An axial direction of the tool 30 is the drawing processing direction, The moving direction of the tool 30 along to the inner peripheral face of the female die 20 is a radial direction of the tool 30.

[0026] By doing this, the material 10b is deformed in a narrow portion between the female die 20 and the tool 30 and only a small and uniform distortion is given incrementally, so that the flatness of the bottom plate 11 is kept satisfactorily.

[0027] In addition to the above, since the molded product is formed by restricting the flange 12 overall the periphery by the female die 20, the molded product that the flange does not expand outside and the perpendicularity between the flat plate portion and the flange portion is outstanding can be produced. Particularly, although the flange 12a at the corner is apt to be expanded outside by forming, as shown in Fig. 3, the flange 12a is restricted from outside by the female die 20, so that the flange 12a becomes perpendicular. Namely, in all range from the first stage to the finish stage of the drawing processing, since the flange 12 is clamped according to the inner peripheral face of the female die 20 and the side face of the tool 30, by restricting the flange 12 from the inner side and the outer side, the drawing processing can be carried out. As a result, the processing having a good perpendicularity etc. can be carried out. When to the end portion of the cylinder the flange 12 is overlapped and welded, they can be welded easily.

[0028] As stated in above, in the incremental forming using the female die 20, the seat 40 is installed on the inner periphery side of the female die 20 and the material 10b is fixed to the seat 40, so that the material 10b can be fixed and the predetermined forming can be carried out. The same may be said with a case that the forming progresses and the flange 12 is positioned on the perpendicular surface of the female die 20. Further, the end portion of the material 10b is moved to direct in the inner peripheral face of the female die 20 and is carried out the drawing processing, further the end portion of the material 10b is positioned to the inner peripheral face of the female die 20 and is carried out the drawing processing. As a result, the perpendicularity formed by the flange 12 and the bottom face 11 can be formed ac-

curately. Further, the height of the flange 11 can be made large. Further, the reduction of the plate thickness of the flange 12 can be restrained.

[0029] Further, since the end portion of the material 10b is moved into the female die 20 and is carried out the drawing processing, when the material 10b is taken into the consideration about the shape of the forming, after the forming, it is unnecessary to cut off the end portion of the flange 12. Further, the flange is fixed by the seat 40, the positioning thereof can be carried out the guidance of the pins 23 etc.

[0030] Since a high load like a press forming is not required, the female die 20 may be made of a simple material such as a general steel material and does not require a heat treatment such as hardening and a minute surface finishing like a press die.

[0031] A processing machine for executing the incremental forming is a numerical control processing machine, for example, an NC milling machine or a machining center. In the main shaft (the spindle) of the numerical control processing machine, the tool 30 is installed. The main shaft is moved along to the inner surface of the female die 20 and in the vertical direction by the numerical control. The numerical control processing machine shown in Fig. 1 is a longitudinal one. The main shaft having the tool 30 can be moved in the vertical direction and one direction of the horizontal direction. The female die 20 and the seat 40 are mounted on the table (the base). The table can be moved in the horizontal direction of the perpendicular direction to the moving direction of the horizontal direction of the main shaft. According to these two moving, the tool 30 can be moved along to the inner peripheral face of the female die 20. The ascending and descending apparatus 50 is mounted on the table. In place of the vertical direction moving of the tool 30, the table can be moved up and down.

[0032] An example will be explained hereunder. The diameter of the tool 30 is 25 mm, and the plate thickness of the material 10b is about 0.5 mm to 4 mm, and the distance from the inner peripheral face of the female die 20 to the side face of the tool 30 is about 0.8 to 2 times of the plate thickness, and the forced depth of the tool 30 per each time (the descendent distance of the seat 40 per each time) is 0.5 to 2 times of the plate thickness of the material 10b, and the height of the flange 12 is about 5 to 20 times of the plate thickness of the material 10b. Further, the height of the flange 12 is 20 mm, the radius of the circular arc portion (the shoulder portion) of the female die 20 is 5.5 to 13.5 mm, the diameter of the tool 33 us 25 mm, the radius of tip end of the tool 30 is 5.5 to 10 mm and the radius of the circular arc portion 12a is 100 mm.

[0033] The size of the material 10b will be explained. As shown in Fig. 1, the end portion of the material 10b has the size which is positioned to the upper portion of the circular arc R of the shoulder portion of the female die 20 or to the center side of the female die from the upper portion of the above stated center. When the size is larger than the above, in the circular arc portion 12a of the flange, the cracks can occur easily in the connection portion of the flange 12 and the bottom plate 11.

[0034] In the above embodiment, as shown in Fig. 6, to the connection portion of the linear portion 12b and the circular arc portion 12a of the flange 12 the wrinkle 12c occurs easily. With the proportion of the height of the flange 12 becomes large, the wrinkle 12c occurs easily. In Fig. 6, so to be easily understood the wrinkle is shown with exaggeration. As shown in Fig. 7, the linear portion of the flange 12 is inclined linearly from the bottom plate 11. As shown in Fig. 8, the circular arc portion 12b of the flange 12 is along to the circular arc of the shoulder portion of the female die 20. Therefore, when the wrinkle 12c begins to occur according to the progression of the drawing processing, the drawing processing is made to stop, and to the circular arc portion of the female die 20 the process for restraining the wrinkle and for smoothing the flange 12 is carried out. Hereinafter, this process will be explained referring to Fig.9A to Fig. 9C.

[0035] When it reaches to the stage in which the wrinkle 12c occurs, the drawing process shown in Fig. 9A (namely Fig. 1) is made to stop, then the descendant of the seat 40 is stopped. And, as shown in Fig. 9B, the tool 30 is moved up slightly and further the tool is moved slightly in the outside of the female die 20. Namely, under the condition where the material 10b is clamped to the circular arc portion of the shoulder portion of the female die 20, the tool 30 is gone round. According to the demands, the tool 30 is moved up slightly and further the tool is moved slightly in the outside of the female die 20 and under the condition where the material 10b is clamped to the circular arc portion of the shoulder portion of the female die 20, the tool 30 is gone round. This operation is carried out necessary several times. Next, as shown in Fig. 9C, the tool 30 is made to return to the position of Fig. 9A (namely, Fig. 1) and the drawing process of Fig. 9A (namely, Fig. 1) is restarted. Namely, the seat 40 and the tool 30 are moved down and the tool 30 is gone round. After the restart of the drawing process, when the wrinkle 12 begins to occur, then the above stated wrinkle restraining process is restarted.

[0036] The occurrence of the wrinkle whether what times of the drawing processes are necessary is understood from the experimentation, in a midway of the drawing process the wrinkle restraining process can be built in advance. By summing up the descendent of the seat 40 and the tool 30 and the one round of the tool 30 in the peripheral direction of the female die 20, one time drawing process is constituted.

[0037] In the above stated embodiment, after the seat 40 has moved down and then the tool 30 is moved down. However, they may be moved down at the same time. Further, it may unnecessary to make the tip end of the tool flat and also it may unnecessary to rotate the tool 30.

[0038] In the above stated embodiment, the diameter of the tool 30 is uniform. Therefore, until immediately

before the completion of the forming, the tip end portion of the flange 12 is in contact with the side of the tool 30. The tip end portion of the flange 12 comes in contact with the side of the tool 30 every revolution time of the tool 30. When a failure occurs due to it, the diameter of the tool 30 at the position which is opposite to the tip end portion of the flange 12 is reduced.

[0039] In the above stated embodiment, the incremental forming is performed in a state that the tool 30 and the seat 40 clamp the material. However, the incremental forming in the clamped state is not necessary. Therefore, at a desired point of time, the descendent distance of the seat 40 is made longer than the descendent distance of the tool 30. There is an interval larger than the plate thickness of the material 10b between them. Thereafter, the two are moved down with the interval kept. At the last stage of the drawing processing, the tool 30 and the seat 40 are moved down so as to clamp the bottom plate 11 by the tip end portion of the tool 30 and the seat 40. In the clamping state, the tool 30 is moved in the peripheral direction.

[0040] According to this, during the incremental forming, the outer periphery of the bottom plate 11 is not clamped by the seat 40 and the tip end of the tool 30. Therefore, the plate is not partially made thinner. The bottom plate 11 is fixed to the seat 40 in a bent state. At the final stage, the seat 40 and the tip end of the tool 30 clamp the bottom plate 11 and the incremental forming is carried out, so that the flatness of the bottom plate 11 and the angle between the bottom face 11 and the flange 12 are set as specified.

[0041] The seat 40 is fixed, and the female die 20 is moved up, and the drawing can be carried out. The tool 30 neither moves vertically during the forming. The seat 40 is positioned in the position of the axial direction of the tool 30 and along to the inner peripheral face of the female die 20. In the embodiment shown in Fig. 1, the vertical load according to the tool 30 is added to the seat 40 (the ascendant and descendent device 50). The seat 40 (45) moves in the vertical direction. As a result, the seat 40 (45) is inclined easily and moves down easily further from the predetermined position. For this reason, it is hardly produce the molded product having the high accuracy. To prevent this, it is necessary to constitute strongly the ascendant and descendent device 50 which supports the seat 40 and the apparatus becomes high cost. However, it hardly add the vertical load according to the tool 30 to the female die 20. For this reason, when the female die 20 is made to move, the above stated problems hardly occur, and the molded product having the high accuracy can be produced and the apparatus can be constituted with the low cost. In this case, during the female die 20 is made to move, it can stop the movement of the tool 30. Further, during the female die 20 is made to move or before of this, the tool 30 is moved up, after the ascendant of the female die 20, the tool 30 may be moved down.

[0042] The embodiment shown in Fig. 10 will be explained hereinafter. The female die 20 has a bottom portion 21. The width of the bottom portion 21 is equivalent to the diameter of the tool 30. When the tool 30 moves down to the lowest end position, the tip end of the tool 30 and the tip end of the bottom portion 21 clamp the material 10b. The diameter of the seat 40 is smaller than the inner diameter of the bottom portion 21. The descendent (lowering) distance of the tool 30 is practically the same as that of the seat 40. The descendent (lowering) distance of the seat 40 is controlled so that the bottom plate 11 of the material 10b will not be deformed. At the final stage of the drawing processing, the height position of the seat 40 is adjusted to the height position of the bottom portion 21. In the state that the tip end of the tool 30 and the bottom portion 21 clamp the material 10b, the tool 30 is moved along the inner peripheral direction of the female die 20.

[0043] According to this, it is sufficient to manufacture only the female die 20 so as to withstand the drawing processing of the tool 30.

[0044] When the size of the outer peripheral portion of the seat 40 is provided larger than the size of the inner peripheral portion of the bottom portion 21 of the female die 20, and when the seat 40 is moved down the lowest end position, the outer peripheral portion of the seat 40 is mounted on the bottom portion of the female die 20. According to this, in the final processing stage, by the female die 20 which is not moved, the seat 40 is supported, the occurrences of the above stated problems can be restrained. Further, at always, the material 10b can be clamped by the seat 40 and the tool 30.

[0045] Further, when the seat is fixed and the female die 20 is moved, in the axial direction of the tool 30 and along to the peripheral direction of the peripheral face of the female die 20, the seat 40 is provided. When the female die 20 is ascended the most upper end position, between the outer peripheral portion of the seat 40 and the tool 30, the material 10b is clamped. According to this in the final processing stage, by the seat 40 which is not moved, the material 10b is supported, the occurrences of the above stated problems can be restrained.

[0046] The embodiment shown in Fig. 11 will be explained hereinafter. In this embodiment, the height of the flange 12 in the previous embodiment is increased. The movement of the seat 40 and the lowering of the tool 30 are the same as those shown in the previous embodiment. Only the different points will be explained hereinafter.

[0047] The circular arc of the tip end portion of the female die 20 on the inner peripheral face side is comparatively large. The circular arc is expanded upward. The material 10b is mounted on the female die 20 and fixed to the seat 40. The movement of the tool 30 will be explained mainly. Namely, when the outer end portion of the material 10b is mounted on the female die 20, in the state that between the circular arc portion of the female die 20 and the tip end portion of the tool 30, the outer end portion of the material 10b is clamped, the tool 30

is moved in the peripheral direction of the female die 20. When it makes a round, the tool 30 is moved on the inner peripheral face side (downward) along the circular arc portion of the female die 20. In the state that the material 10b is clamped between the circular arc portion of the female die 20 and the tip end portion of the tool 30, the tool 30 is moved in the peripheral direction of the female die 20. In the same way as with the embodiment shown in Fig. 1, when the tool 30 is to be moved down, the seat 40 is moved down.

[0048] When the tool 30 passes through the circular arc portion of the female die 20b in this way, the tool 30 is positioned in the same location as that of the embodiment shown in Fig. 1. Namely, in the state that the material 10b is positioned between the side face of the tool 30 and the inner peripheral face of the female die 20, the tool 30 is moved in the peripheral direction of the female die 20. The incremental operation hereinafter is the same as that of the embodiment shown in Fig. 1.

[0049] Namely, by pressing by the tip end of the tool 30 from the outer periphery of the material 10b mounted on the tip end of the female die 20, the tool 30 is moved along the circular arc R from the tip end of the female die 20 to the inner peripheral face. And, the material 10b is positioned between the vertical face of the female die 20 and the side face of the tool 30. This movement is carried out by the numerical control.

[0050] By doing this, the outer peripheral portion of the material 10b is formed by getting to fit the circular arc of the shoulder of the female die 20, so that wrinkles are suppressed and drawing forming with a high flange can be realized. Particularly, when the corner portion 12a of the flange 12 is to be formed, it can be formed by preventing wrinkles from generation.

[0051] The embodiment shown in Fig. 12 will be explained hereinafter. A press seat 60 for restricting the outer peripheral portion of the material 10b to the female die 20 is provided. A bolt 62 presses the press seat 60 to the female die 20 via a coil spring 61. In this state, the incremental forming is carried out in the same way as with the embodiment shown in Fig. 1. The press seat 60 presses the material 10b to the female die 20 to make to move the tip end portion of the material 10b in the inner peripheral side of the female die 20. When the drawing depth increases, the outer peripheral portion of the material 10b is dislocated from the press seat 60 and released from the restriction, and the end portion of the material 10b is positioned on the inner peripheral face of the female die 20.

[0052] The embodiment shown in Fig. 13 will be explained hereinafter. The tool 30 has a ring 35 equivalent to the press seat 60. The outer diameter of the ring 35 is larger than the outer diameter of the tool 30. The ring 35 is pressed downward by a coil spring 36. The ring 35 can move in the axial direction of the tool 30. Numeral 38 indicates a cylindrical member fixed to the ring 35 so as to prevent the ring 35, etc. from coming out. A guard 38b at the tip end of the member 38 is structured so as to get caught in a guard 30e of a large diameter portion 30D of the tool 30. Numeral 37 indicates a seat. The position of the tool 30 is the same as that of the embodiment shown in Fig. 1.

[0053] According to this, in the early stage of forming, the ring 35 presses the outer peripheral portion of the material 10b to the tip end portion of the female die 20. Therefore, the outer peripheral portion of the material 10b is formed by getting to fit the circular arc portion at the tip end of the female die 20. As a result, the generation of wrinkles is suppressed and the drawing forming with a high height flange can be realized.

[0054] The embodiment shown in Fig. 14 will be explained hereunder. A material 10e is a preformed material which is formed in advance in a shape approximated to the target shape to be obtained by incremental forming. A flange 12c of the outer peripheral portion of the preformed material 10e is expanded upward in a bugle shape. In the early stage, the flange 12e is in contact with the circular arc portion of the female die 20 at the upper end. The position of the tool 30 is the same as that of the embodiment shown in Fig. 1.

[0055] The flange 12e having the length finally required is inclined and installed in advance, so that the generation of wrinkles and the cracking of the plate of the incrementally forming portion can be prevented. The preformed material 10e is manufactured by the press forming or the incremental forming.

[0056] The embodiment shown in Fig. 15 will be explained hereunder. A preformed material 10g is preformed so that the outermost peripheral portion almost coincides with the inner peripheral face of the female die 20. The flange 12g is expanded in a bugle shape. The tip end portion of the flange 12g is mounted on the circular arc portion of the female die 20. The preformed material 10g is mounted and fixed on the seat 40. The tip end of the tool 30 is in contact with the bottom plate of the material 10g. The bottom plate of the material 10g is clamped between the tip end of the tool 30 and the seat 40. The side face of the tip end of the tool 30 is positioned on the boundary of the bottom plate of the material 10g and the flange 12g.

[0057] In this state, the tool 30 is moved toward the vertical face side of the female die 20 and then moved in the peripheral direction along the vertical face of the female die 20. Namely, the tool 30 makes a round so as to press and expand the flange portion on the outer periphery side. Every one round, the gap with the female die 20 is narrowed to about 0.5 to 2 times of the plate thickness. The seat 40 does not move down.

[0058] The preformed material 10g can be manufactured by the incremental forming like the embodiment shown in Fig. 1. Then, it can be incrementally formed continuously like the embodiment shown in Fig. 14 or Fig. 15.

[0059] The embodiment shown in Fig. 16 and Fig. 17 will be explained hereunder. A flange 112 of this embodiment is provided only on one side of a substantially four-

sided figure. Such a flange is not provided overall the outer peripheral portion of a material 110. The side on which the flange 112 is provided is circular arc shape. The material 110 is an extruded frame material of aluminum alloy and it has a rib 110r on the upper face side. The rib has a T-shaped section.

[0060] The rib 110r where the flange 112 is to be installed is cut and removed beforehand. The thickness of the face plate 111 of the frame member 110 is generally thicker than the thickness suited to incremental forming, so that the face plate 111 of the portion where the flange 112 is to be installed is cut and formed as a thin plate 111b. This cutting is carried out, for example, by an end milling. The cutting range L of each of the face plate 111 and the rib 110r is decided by the movement range of a tool 130.

[0061] A female die 120 is sufficient to have only the portion of the flange 112. Numeral 150 indicates a restricting metal for clamping and fitting the face plate 111 of the frame member 110 by the seat 140. The metal fitting 150 clamps the face plate 111 of the frame member and the seat 140 in the upper and lower direction. When a hole may be formed in the face plate 111, it is clamped by a bolt and nut and fixed to a seat 140.

[0062] The flange 112 is provided only at a part, so that there is no need to rotate the rod shape metal fitting 130 round the inner peripheral face of the female die 120. The rod shape metal fitting 130 is sufficient to move back and forth in the direction of the arrow as shown in Fig. 16. In both of the reciprocating motion, the material can be incrementally formed. To the four-sided shape material, the flange to be incrementally formed can be processed in a case where they exist the three sides and the two opposed sides.

[0063] The embodiment shown in Fig. 18 and Fig. 19 will be explained. As shown in Fig. 18, a molded product 210 of this embodiment has a flange 212 at an end portion of a bottom plate 211 and to the bottom plate 211 plural lines ribs 215 are provided. A bottom face of the rib 215 is comparatively wide. The flange 212 has a substantially four-sided shape bottom plate. The rib 215 projects a side opposed the projection direction of the flange 212.

[0064] A manufacturing process will be explained referring to Fig. 19. A flat plate shape material 210b is mounted on a female die 220 and a seat (a die) 240, the end portions of the four sides of the material 210b are pressed to the female die 220 by a fitting metal 225 and fixed. An upper face of the female dire 220 and an upper face of the seat 240 are substantially the same height. To an upper face of the seat 240 plural lines recessed portions 245 having the size corresponded to the rib 215 are provided. A depth of the recessed portion 245 is larger than the height of the rib 215 (Fig. 19A).

[0065] To the position where the rib 215 is provided, the tool 30 is positioned, and the tool 30 is moved down, the tool 30 is moved to the peripheral portion along to the recessed portion 245 and then the rib is provided. This processing is the sponson processing. When the tool 30 is gone round with one round along to the recessed portion 245 and the tool 30 is moved to the position where another rib 215 is provided and the sponson processing is carried out similarly. As a result, the ribs 215 are provided in order. Further, the descendent amount of the tool 30 is smaller than the height of the rib 215.

[0066] The tool 30 is gone round with one round along to all of the recessed portions 245 and further the tool is moved down and is gone round along to the recessed portion 245. Similarly at the position of the another rib it is carried out. This is repeated the necessary times. As stated above, all of the ribs are formed little by little in order (Fig. 19B).

[0067] When the ribs 215 having a predetermined number are formed, the metal fitting 225 is removed, and then the material 210b is fixed to the seat 240 by the electromagnet force or the vacuum adsorption. (Fig. 19C)

[0068] Next, the drawing processing for providing the flange 212 to the end portion of the material 210b is carried out according to the movement of the tool 30 and the female die 220 (or the seat 240) similarly to the above stated embodiment (Fig. 19D). When the molded product 210 is large, it is desirable to fix the seat 240 and move the female die 220.

[0069] The embodiment shown in Fig. 18 and Fig. 19 can utilized in a case where the flange is not provided but the plural ribs 215 are provided. The fixing of the material 210b may be fixed to the seat 240.

[0070] A case where the cross-section shape of the rib 215 has a substantially tri-angle shape will be explained. The descendent position of the tool 30 is that between the end portion of the recessed portion of the seat 240 and the side face of the tool 30 a gap having more than the plate thickness is provided. Further, to the connection portion of the rib 215 and the bottom plate 211 a predetermined circular arc is provided. In this embodiment, the flanges 212 are provided on the four sides but similarly to the flanges are provided on only three sides.

[0071] The embodiment shown in Fig. 20 and Fig. 21 will be explained. As shown in Fig. 20, a molded product 310 of this embodiment has a flange 312 at an end portion of a bottom plate 311 and to the bottom plate 311 plural lines ribs 315 are provided. A bottom face of the rib 315 is comparatively wide. The flange 212 has a substantially four-sided shape bottom plate. The rib 315 projects same direction to the projection direction of the flange 312.

[0072] A manufacturing process will be explained referring to Fig. 21. A flat plate shape material 310b is mounted on a female die 320 and a seat (a die) 340, the end portions of the four sides of the material 310b are pressed to the female die 320 by a fitting metal 325 and fixed. An upper face of the female dire 320 and an upper face of the seat 340 are substantially the same height.

To an upper face of the seat 340 plural lines raised portions 345 having the size corresponded to the rib 315 are provided. A size 8 width, length, height) of the raised portion 345 is substantially same to the size of the rib 315 (Fig. 21A).

[0073] In the position where the rib 315 is provided and from the position where the tip end of the tool 30 is contacted to the upper face of the material 310b, and the tool 30 wand the female die 320 are moved down, the tool 30 is moved to the peripheral portion along to the raised portion 345 and then the rib is provided. This processing is the sponson processing. When the tool 30 is gone round with one round along to the raised portion 345 and the tool 30 is moved to the position where another rib 315 is provided and the sponson processing is carried out similarly. As a result, the ribs 315 are provided in order. Further, the descendent amount of the tool 30 is smaller than the height of the rib 315.

[0074] The tool 30 is gone round with one round along to all of the raised portions 345 and further the tool is moved down and is gone round along to the raised portion 345. Similarly at the position of the another rib it is carried out. This is repeated the necessary times. As stated above, all of the ribs are formed little by little in order (Fig. 21B).

[0075] When the ribs 315 having a predetermined number are formed, the metal fitting 225 is removed, and then the material 210b is fixed to the seat 240 by the electromagnet force or the vacuum adsorption. (Fig. 21C)

[0076] Next, the drawing processing for providing the flange 312 to the end portion of the material 310b is carried out according to the movement of the tool 30 and the female die 320 (or the seat 340) similarly to the above stated embodiment (Fig. 21D). Since the formation of the raised portion 345, the female die 320 is moved, in a case of the formation of the flange 320 since the female die 320 is moved, the constitution can be made simply.

[0077] The embodiment shown in Fig. 20 and Fig. 21 can utilized in a case where the flange is not provided but the plural ribs 315 are provided.

[0078] The embodiment shown in Fig. 22 will be explained. At a surrounding portion of a hole 417 of a molded product 410, a burring 418 is provided. A projection direction of the burring 418 is a reverse direction to a projection direction of a flange 412 of an outer peripheral portion of the molded product 410. To a material in which the burring 418 use hole 417 is provided, a burring processing is carried out. The processing procedure is similarly to that of Fig. 19. The recessed portion 245 becomes the burring 418 use recessed portion. A case of the provision of the plural burring is similarly to.

[0079] When the projection direction of the burring and the projection direction of the flange 412 of the outer peripheral portion of the molded product are the same, the procedure similar to that of Fig. 21 is carried out. The raised portion 345 becomes the burring use raised portion. A case of the provision of the plural burring is similarly to.

[0080] It can be applied that to the female die the vacuum adsorption pad and the electromagnet are provided and according to these the material is fixed and along to the outer periphery of the material the incremental formed is carried out using the tool.

[0081] The technical scope of the present invention is not limited to the text described in each claim of the patent or the text described in the item of the means of solving the problems and applicable to a claim with which it is easily replaced by those who are skilled in the art in the field of the present invention.

[0082] According to the present invention, in a method for incrementally forming using a female die and a tool, it can be easily formed in a predetermined shape.

Claims

1. An incremental forming method, wherein

   under a condition where a material is fixed to a seat arranged on an inner side of a female die, between said female die and a tool member and between said seat and said tool member, said material is arranged, and under a condition where an outer end portion of said material is capable to move in a drawing processing direction;
   said seat and said tool member are relatively moved in said female die according to a drawing processing direction; and
   said tool member is relatively moved along an inner peripheral face of said female die.

2. An incremental forming method according to claim 1, wherein

   after said tool member has relatively moved along to said inner peripheral face of said female die;
   said seat and said tool member are relatively moved to said female die in said drawing processing direction; and
   said tool member is relatively moved along to said inner peripheral face of said female die.

3. An incremental forming method according to claim 1, wherein

   said tool member is moved to said drawing processing direction and an outer end portion of said material is moved to an inner side of said female die.

4. An incremental forming method according to claim 1, wherein

   said tool member is moved in said drawing

processing direction and an outer end portion of said material is moved from an end face of said female die to said inner peripheral face of said female die.

5. An incremental forming method according to claim 1, wherein

under a condition where an outer end portion of said material is positioned in an inner peripheral face of said female die according to said drawing processing, said tool member is relatively moved along to said inner peripheral face of said female die.

6. An incremental forming method according to claim 1, wherein

said material is substantially a four-sided plate, and a corner portion or one side of said material is a circular arc shape plate.

7. An incremental forming method according to claim 1, wherein

a guide which is arranged vertically in an outer peripheral portion of said female die;
under a condition where said outer end portion of said material is contacted to said guide, said material is mounted on said female die; and
said material is fixed to said seat.

8. An incremental forming method according to claim 1, wherein

said material is fixed only to said seat.

9. An incremental forming method according to claim 1, wherein

between an inner peripheral face of said female die and a side face of said tool member, said material is clamped, and said tool member is relatively moved along to said inner peripheral face of said female die.

10. An incremental forming method according to claim 1, wherein

said seat is arranged in an axial direction of said tool member;
under a condition where between said seat and a tip end of said tool member, said material is clamped, said tool member is moved along to an inner periphery face of said female die.

11. An incremental forming method according to claim 1, wherein

at a final stage of said drawing processing, said material is clamped by a tip end of said tool member and a portion of said female die, said tool member is relatively moved along to said inner periphery face of said female die.

12. An incremental forming method according to claim 1, wherein

in said movement of said seat and said tool member, said seat is relatively moved in said drawing processing direction; and
said tool member is relatively moved in said drawing processing direction.

13. An incremental forming method according to claim 1, wherein

said seat and said tool member are relatively moved at the same time in said drawing processing direction.

14. An incremental forming method according to claim 1, wherein

said female die is moved in said drawing processing direction.

15. An incremental forming method according to claim 1, wherein

a circular arc portion is arranged in a shoulder portion of an end portion of said female die in which said drawing processing is started; and
under a condition where an outer end portion of said material is contacted to said end portion of said female die, said drawing processing is started.

16. An incremental forming method according to claim 15, wherein

after said movement of said seat and said tool member in said drawing processing direction has carried out and after a movement of said tool member in said inner peripheral face of said female die has carried out, said drawing processing is interrupted; and
said tool member is relatively moved in a side of said circular arc portion, and between said circular arc portion and a tip end of said tool member, said material is clamped; under said above stated condition, said tool member is relatively moved along to said inner peripheral face of said female die; and
said tool member is relatively returned in said interrupted portion and said drawing processing is restarted.

17. An incremental forming method according to claim 1, wherein

under a condition where between a circular arc portion of a shoulder portion of said female die

and said tool member an outer end portion of said material is positioned, said tool member is relatively moved along to a peripheral direction of said female die;
said seat is relatively moved to said drawing processing direction and said tool member is relatively moved in said drawing processing direction along to said circular arc portion; and
in said circular arc portion, said tool member is relatively moved along to a peripheral direction of said female die.

18. An incremental forming method according to claim 1, wherein

under a condition where an outer end portion of said material is constrained to one end portion of said female die, said tool member is relatively moved along to said inner peripheral portion of said female die; and
under a condition where in correspondence with a relative movement of said seat and said tool member to said female die in said drawing processing direction, and under a condition where between a side face of said tool member and said inner peripheral face of said female die said outer end portion of said female die is positioned, said tool member is moved along to said inner peripheral face of said female die.

19. An incremental forming method according to claim 1, wherein

said tool member is relatively moved from one end side to another end side along to an inner peripheral face of said female die; and
said tool is relatively moved from said one end side to said another end side.

20. An incremental forming method, wherein

under a condition where a material is fixed to a seat arranged on an inner side of a female die and also in a condition where, between a side face of a tool member arranged on said inner side of said female die and an inner peripheral face of said female die, a flange of said material is positioned, said tool member is moved to said inner peripheral face of said female die in a radial direction thereof; and
said tool member is moved along said inner periphery face of said female die.

21. An incremental forming method, comprising the steps of

forming a plate by cutting off a plate portion of an extruded frame member;
arranging said cut-off extruded frame member in a die, relatively moving a tool member to said die, and relatively moving said tool member in an axial direction of said tool member and said die; and
incrementally forming said cut-off plate.

22. An incremental forming method, comprising the steps of

forming a plate by cutting off a rib provided on a plate portion of an extruded frame member;
arranging said cut-off extruded frame member in a die, relatively moving a tool member to said die in an axial direction of said tool member and said die; and incrementally forming said cut-off plate.

23. An incremental forming method, comprising the steps of

arranging a die in an inner side of a female die, and mounting a material on an upper face of said female die and an upper face of said die;
under a condition where an outer end portion of said material is fixed to said female die, relatively moving a tool member arranged in an upper portion of said material toward a recessed portion provided on said upper face of said die;
carrying out a sponson processing by relatively moving said tool member along to said recessed portion;
releasing said fixing and fixing said material to said die, under a condition where between said female die and said tool member and between said die and said tool member arranging said material;
relatively moving said die and said tool member toward a drawing processing direction to said female die; and
relatively moving said tool member along to an inner peripheral face of said female die.

24. An incremental forming method according to claim 23, wherein

said tool member for said sponson processing and said tool member for said drawing processing are the same tool member.

25. An incremental forming method according to claim 23, wherein

a movement in said drawing processing direction after a release of said fixing is carried out by a movement of said female die.

26. An incremental forming method, comprising the steps of

arranging a die in an inner side of a female die, and mounting a material on an upper face of said female die and an upper face of said die;
under a condition where an outer end portion of said material is fixed to said female die, relatively moving a tool member arranged in an upper portion of said material toward a peripheral portion of a recessed portion provided on said upper face of said die, and moving said female die in a movement direction of said tool member;
carrying out a sponson processing by relatively moving said tool member along to said peripheral portion of said recessed portion;
releasing said fixing and fixing said material to said die, under a condition where between said female die and said tool member and between said die and said tool member, arranging said material;
relatively moving said die and said tool member toward a drawing processing direction in said female die; and
relatively moving said tool member along to an inner peripheral face of said female die.

27. An incremental forming method according to claim 26, wherein

said tool member for said sponson processing and said tool member for said drawing processing are the same tool member.

28. An incremental forming method according to claim 26, wherein

a movement in said drawing processing direction after a release of said fixing is carried out by a movement of said female die.

29. An incremental forming method, comprising the steps of

mounting a material on an upper face of a die having plural recessed portions;
under a condition where said material is fixed to said die, relatively moving a tool member provided on an upper portion of said material toward said recessed portion;
carrying out a sponson processing by relatively moving said tool member along to said recessed portion;
moving said tool member in another recessed portion, and carrying out a sponson processing by relatively moving said tool member along to said recessed portion; and
to a respective portions in which said sponson processing has carried out, carrying out again said sponson processing by a movement of said tool member.

30. An incremental forming method, comprising the steps of

arranging a second die in an inner side of a first die, having plural raised portions on an upper face of said second die;
mounting a material on an upper face of said first die and an upper face of said second die;
under a condition where an outer end portion of said material is fixed to said upper face of said first die, relatively moving a tool member provided on said material toward a peripheral portion of said raised portion, and moving said first die in a movement direction of said tool member;
carrying out a sponson processing by relatively moving said tool member along to said raised portion;
carrying out a sponson processing by relatively moving said tool member along to said raised portion; and
to a respective portions in which said sponson processing has carried out, carrying out again said sponson processing by a movement of said first die and a movement of said tool member.

31. An incremental forming apparatus comprising

a base for mounting a female die and a seat arranged in an inner side of said female die;
a shaft installed on an upper portion of said base and capable to install a tool member directing in a lower portion;
a first movement device for relatively moving said shaft in a vertical direction;
a second movement device for moving one of said seat and said female die in a vertical direction; and
a third movement device for relatively moving said shaft in a horizontal direction along to an inner peripheral face of said female die.

32. An incremental forming apparatus comprising

a base capable to mount a female die;
a shaft installed on an upper portion of said base and capable to install a tool member directing in a lower portion;
a first movement device for relatively moving said a shaft in a vertical direction;
a second movement device for moving one of said seat and said female die in a vertical direction; and
a third movement device for relatively moving said shaft for in a horizontal direction along to an inner peripheral face of said female die.

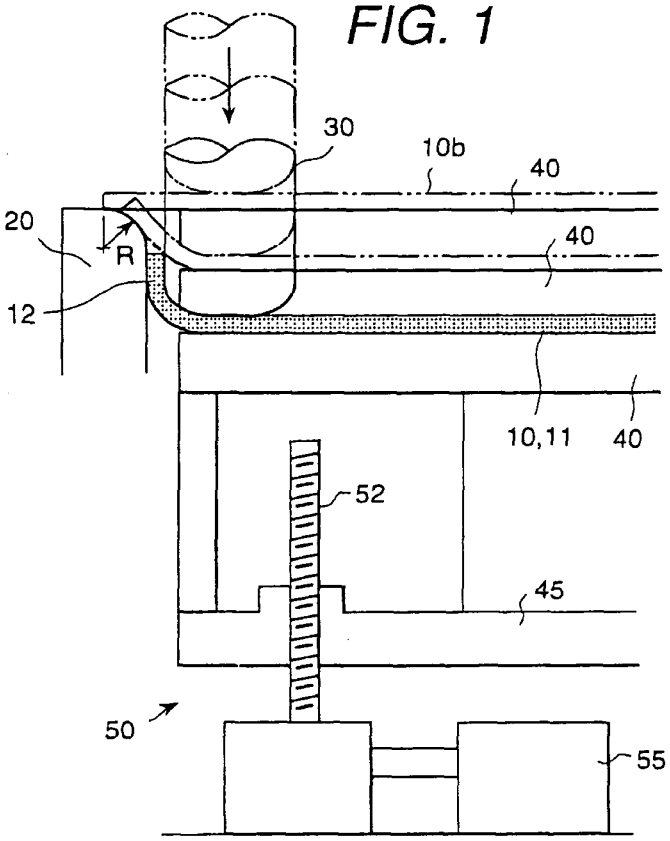
33. An incremental forming apparatus comprising

a base for mounting a female die and a die arranged in an inner side of said female die and having a recessed portion in an upper face;
a shaft installed on an upper portion of said base and capable to install a tool member directing in a lower portion;
a first movement device for relatively moving said shaft in a vertical direction;
a second movement device for moving one of said seat and said female die in a vertical direction; and
a third movement device for relatively moving said shaft in a horizontal direction along to said recessed portion of said die and along to an inner peripheral face of said female die.

34. An incremental forming apparatus comprising

a base for mounting a female die and a die arranged in an inner side of said female die and having a raised portion in an upper face thereof;
a shaft installed on an upper portion of said base and capable to install a tool member directing in a lower portion;
a first movement device for relatively moving said shaft in a vertical direction;
a second movement device for moving said female die in a vertical direction; and
a third movement device for relatively moving said shaft in a horizontal direction along to said raised portion of said die and along to an inner peripheral face of said female die.

FIG. 1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10b
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R
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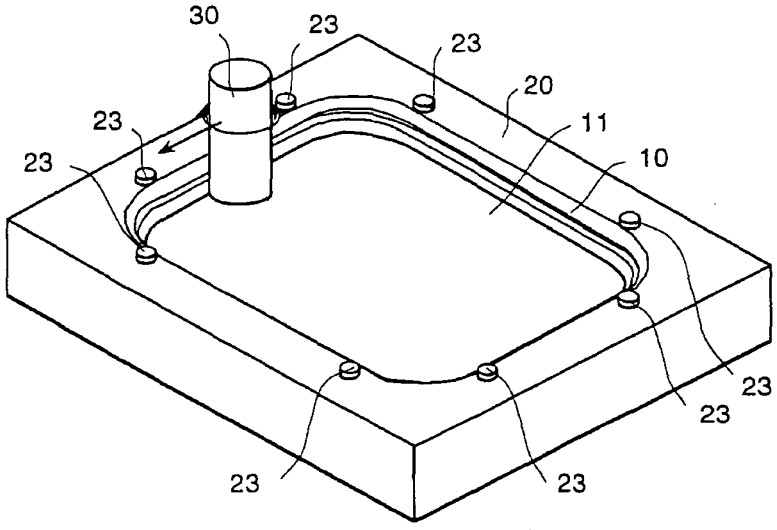
55

FIG. 2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11
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23
23
23

FIG. 3

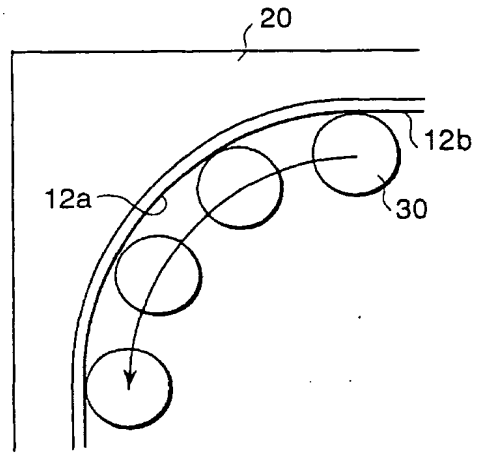


FIG. 4

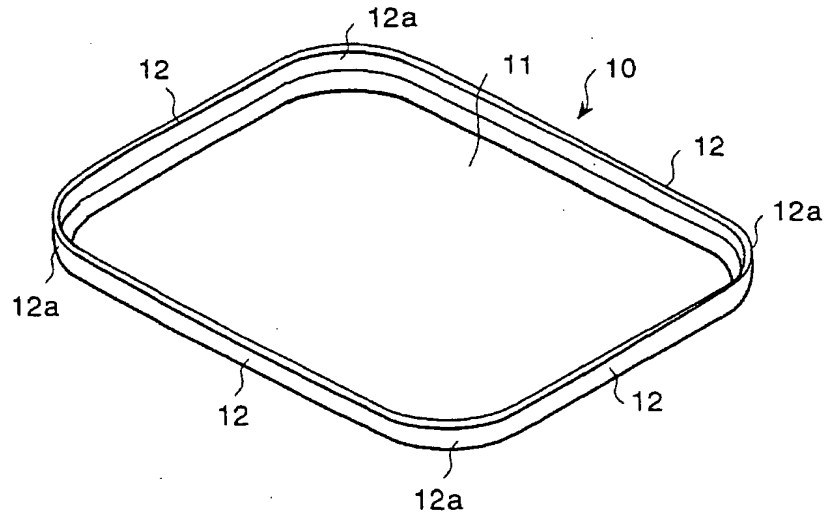


FIG. 5

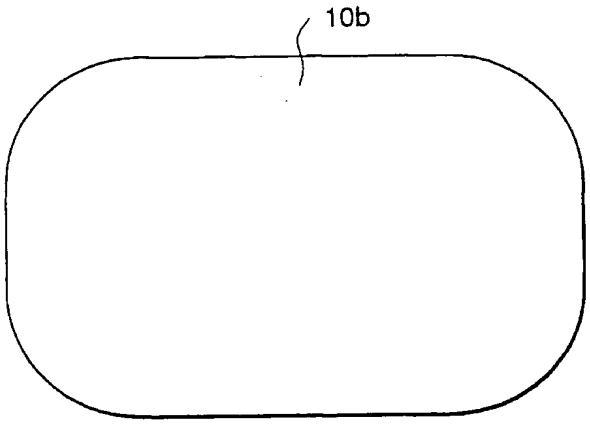


FIG. 6

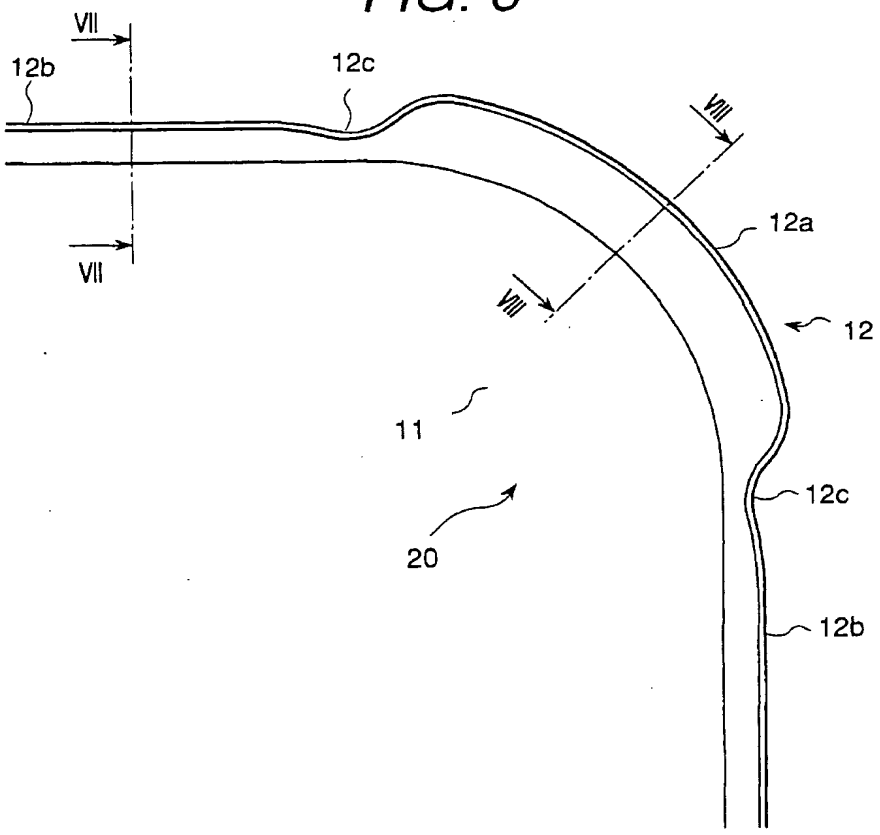


FIG. 7

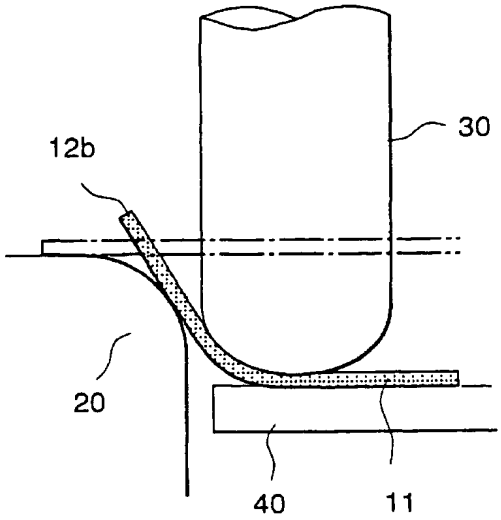


FIG. 8

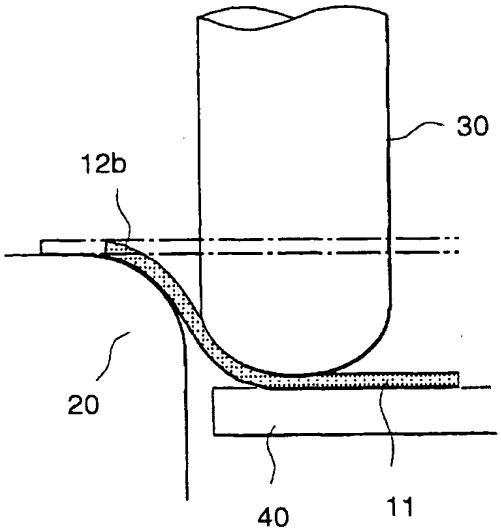


FIG. 9A

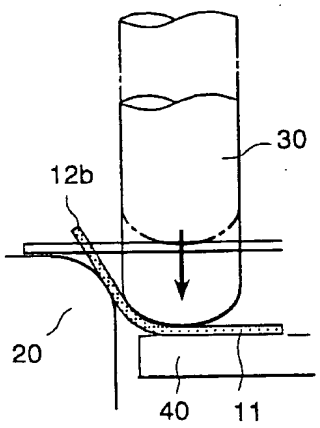


FIG. 9B

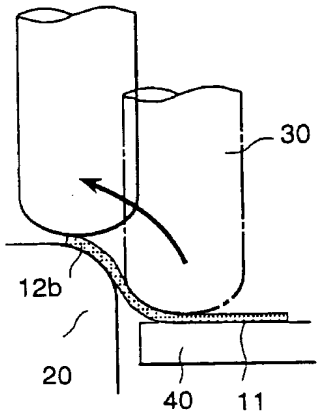


FIG. 9C

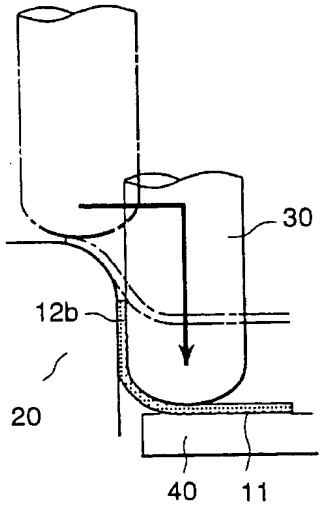


FIG. 10

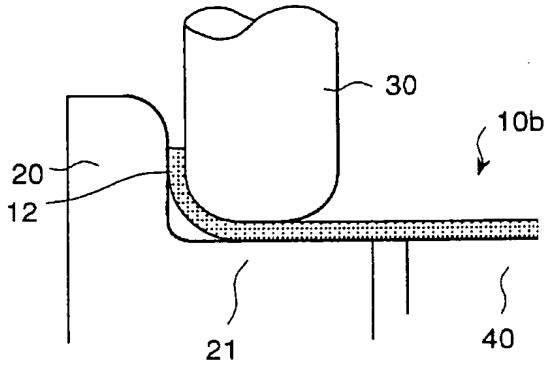


FIG. 11

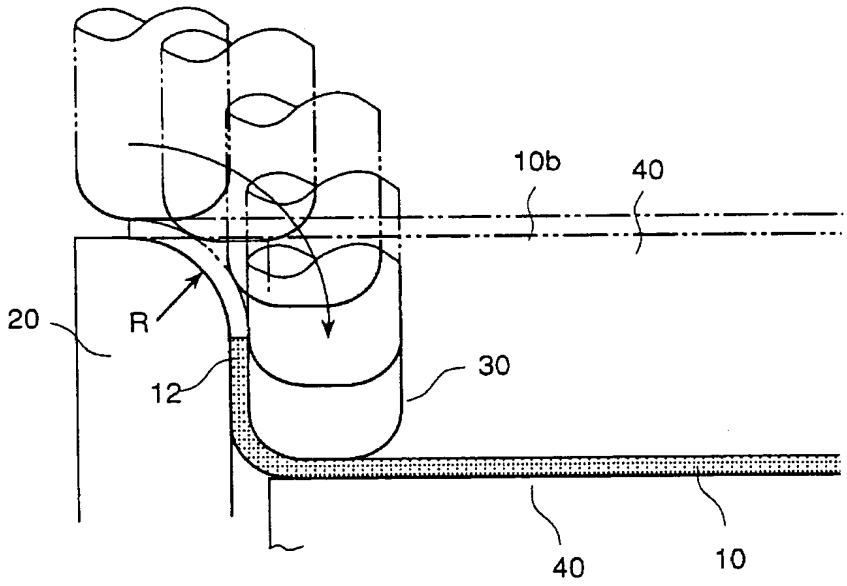
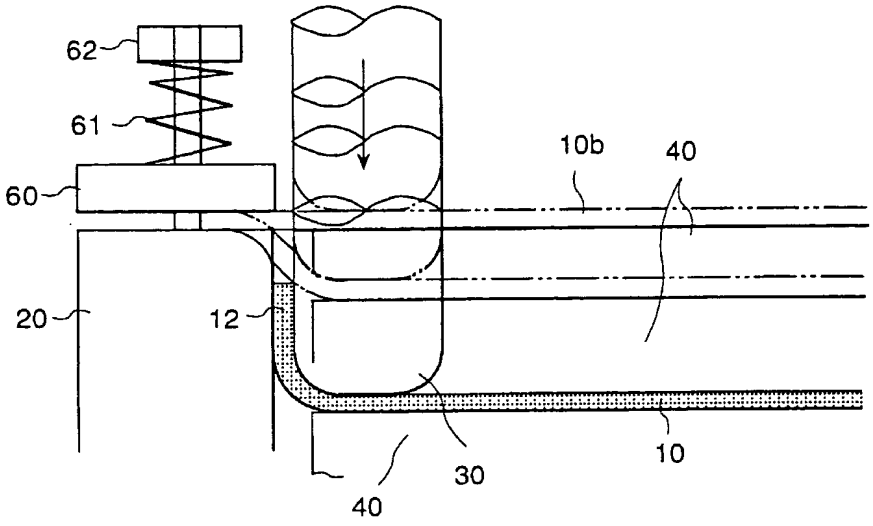


FIG. 12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10b
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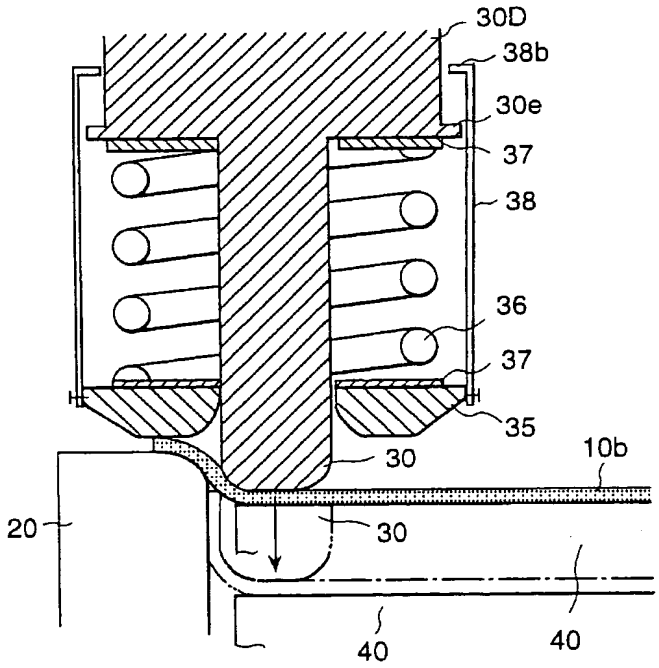
40

FIG. 13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38b
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10b
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40
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FIG. 14

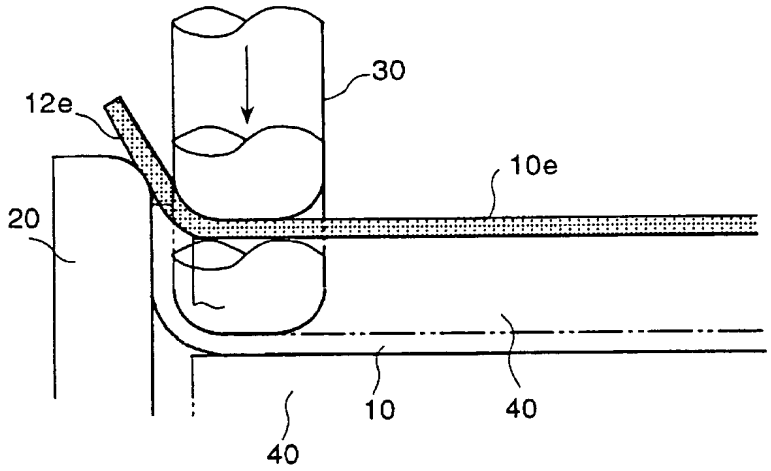

FIG. 15

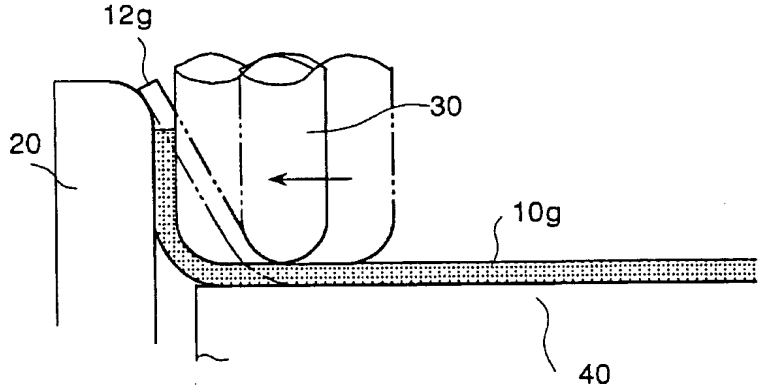

FIG. 16

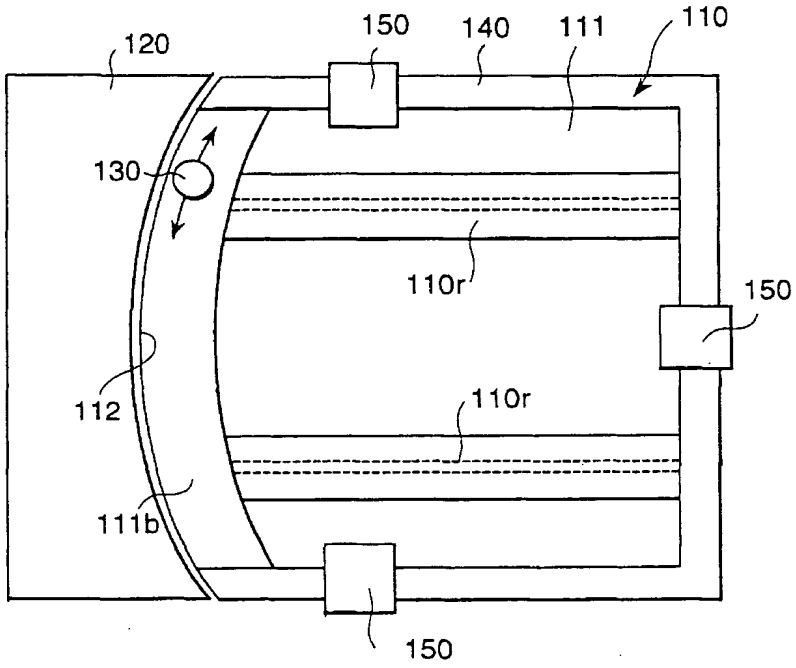
120
150
140
111
110
130
110r
150
112
110r
111b
150

FIG. 17

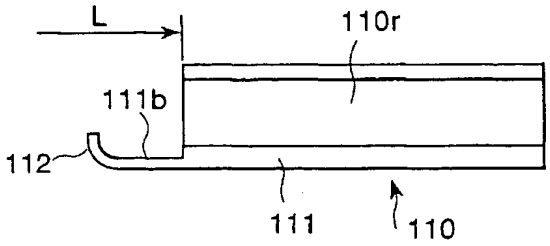
L
110r
111b
112
111
110

FIG. 18

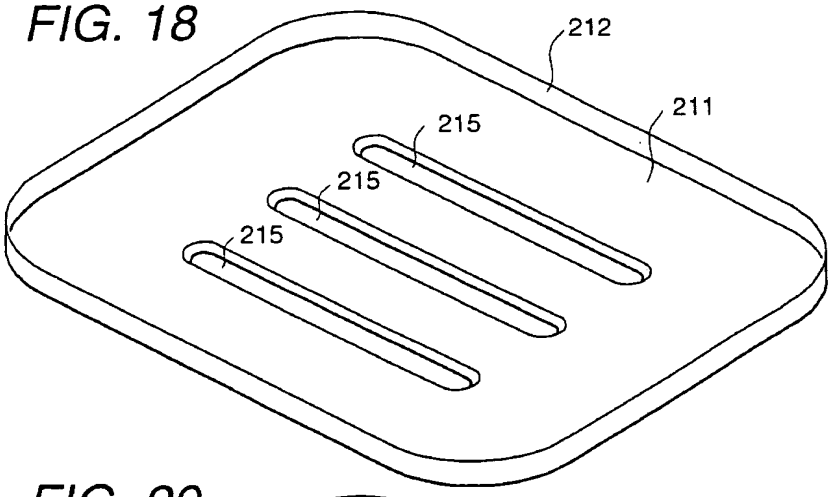

FIG. 20

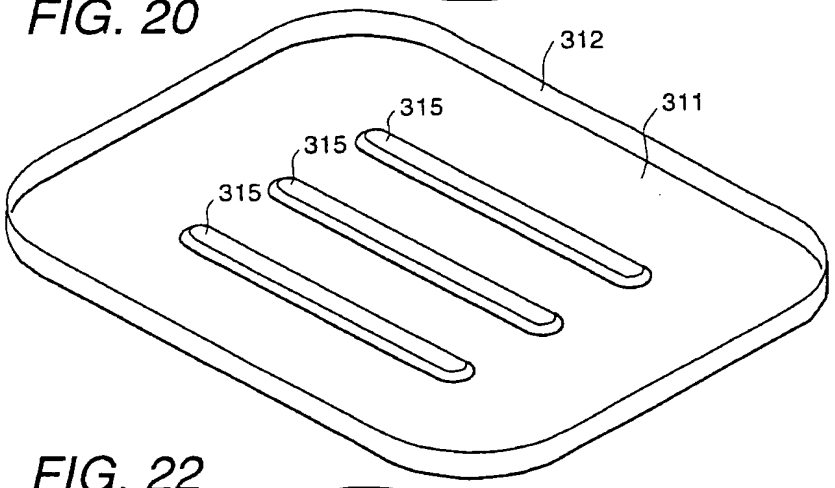

FIG. 22

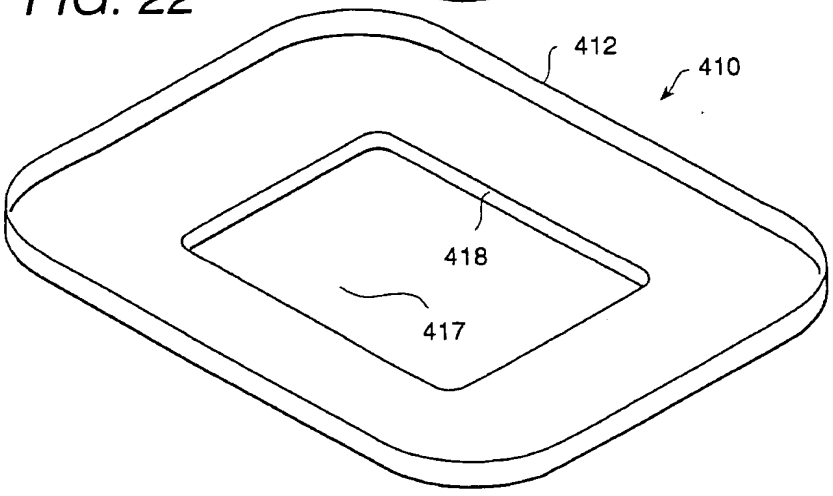

FIG. 19A

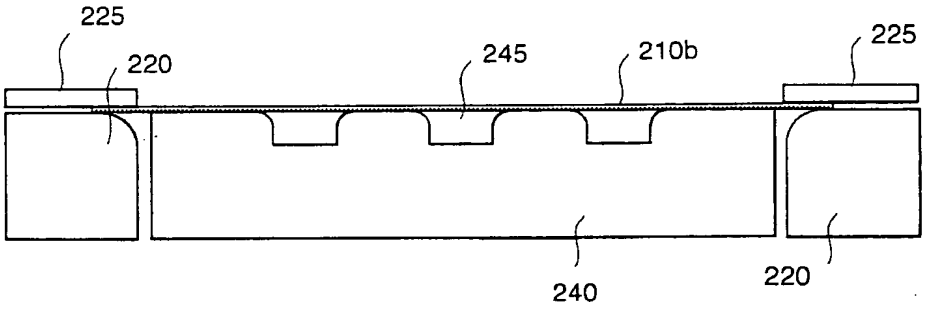

FIG. 19B

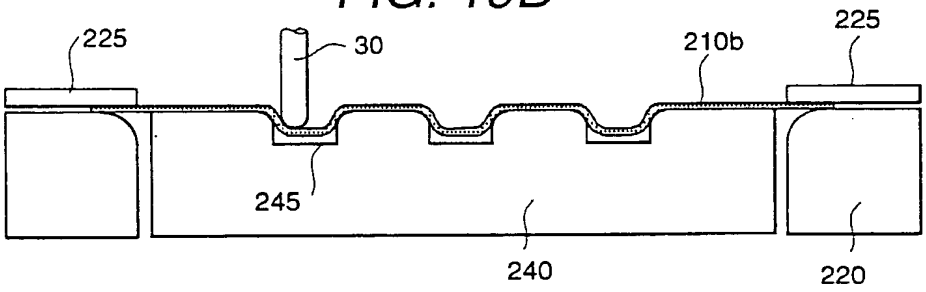

FIG. 19C

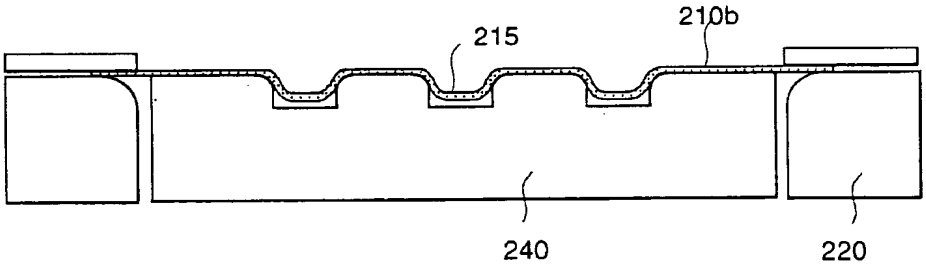

FIG. 19D

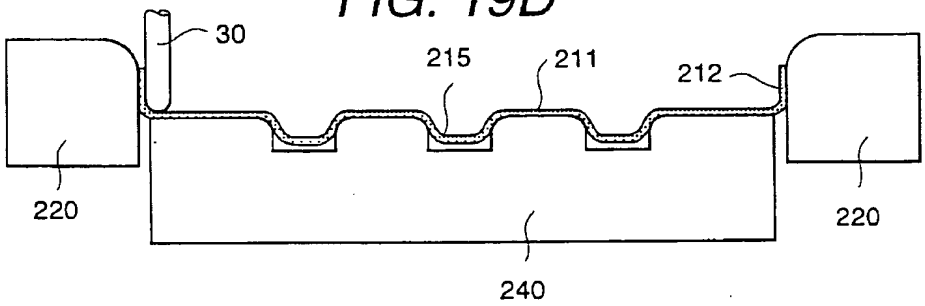

FIG. 21A

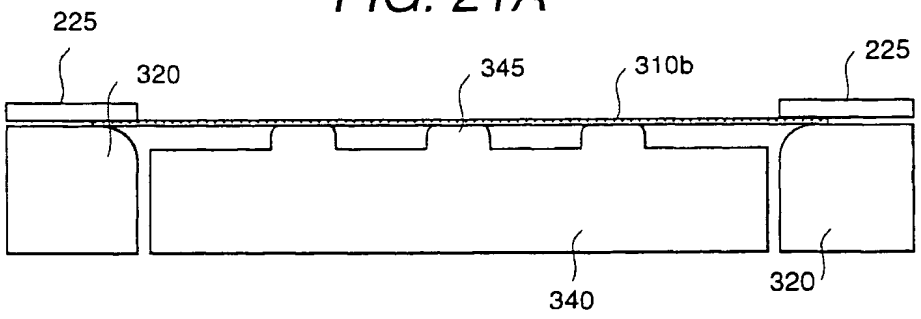

FIG. 21B

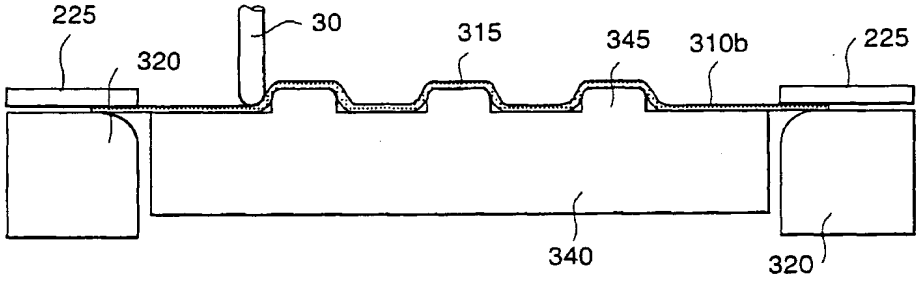

FIG. 21C

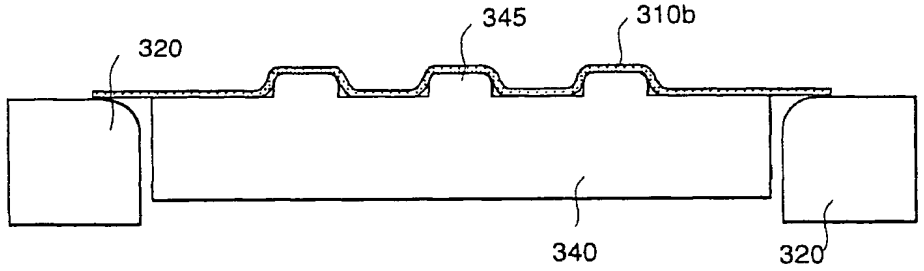

FIG. 21D